BORE HOLE OPENER

RELATED APPLICATIONS

This application is a Continuation application of PCT Application Serial No. PCT/BE02/00031 entitled *Reamer* filed on March 12, 2002, which claims priority to Belgium Application Serial No. 2001/0157 filed on March 12, 2001.

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a bore hole opener, particularly for enlarging a bore hole underneath a casing in the field of oil prospecting.

BACKGROUND OF THE INVENTION

Underreamers are typically used to enlarge the diameter of a bore hole, for one or more of a variety of reasons. It is often necessary for the underreamer to first travel through a casing(s), having a diameter smaller than the diameter desired down-hole of the casing. Accordingly, underreamers are provided with cutting arms that may be retracted during travel through the casing. When a predetermined depth is reached, the cutting arms are actuated to an extended position, and drilling with the underreamer commences. Before an underreamer is brought into service on each occasion, it may be necessary that each arm be locked distinctly in the inactive position. This is to prevent the arms from being deployed unintentionally following variations in the pressure of the fluid passing through the underreamer, until a particular time and/or depth chosen by the operator. In particular therefore, for each new use of a typical underreamer, it is often necessary to remove each arm on each occasion, and possibly the housing thereof, in order to renew the distinct locking means.

In addition, this type of equipment is subjected to very harsh forces under working conditions that are known to be very difficult and therefore very expensive. Firstly, an equipment breakdown may cost significant time, money and resources in attempting to save the equipment, for example jammed at a great depth, and in particular saving the bore hole made at great expense and which, otherwise, could be definitively condemned. Secondly, when the equipment

is recovered, an equipment breakdown must be able to be repaired very easily because the technical repair means available on or close to a drilling platform are sometimes limited.

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SUMMARY OF THE INVENTION

In accordance with a particular embodiment of the present invention, a bore hole opener comprises a body of longitudinal axis, a duct for drilling fluid, formed longitudinally in the body, and having a fluid passage cross section of inside radius i, and at least two hole-opening arms which have an active part equipped with cutting mechanisms, which are arranged in such a way that they can slide between a position of rest in the body and an active position partially out of the body, which are guided and supported for this purpose in the body over a distance g and which, in the active position, project from the body by a length o.

This kind of opening tool has, for example, a body diameter of, for example, between 119 and 427 millimeters. That leaves only a small amount of space in which to build a simple mechanism, provide the aforesaid elements, and give these proportions which give them, and the opener as a whole, a balanced relative solidity.

It is an object of the present invention to provide a solution to this problem and the present invention proposes to observe a given proportional relationship between, on the one hand, the respective values mentioned above for the inside radius i, distance g, length o and, on the other hand, the sum s of these three values.

To this end, according to the invention, the values of i, g and o are chosen to simultaneously satisfy the following conditions:

$I + g + o = s;$

$0.30 < i/s < 0.45,\ 0.40 < g/s < 0.60,\ 0.07 < o/s < 0.20.$

It has been found that these conditions can advantageously be successfully applied to various sizes of hole opener, as explained hereinbelow.

According to one embodiment of the invention, for its sliding guidance in the body, each arm may comprise a cylindrical portion of diameter d, the value of which is at least equal to the value of g above.

According to a particular embodiment of the invention, in order to move it from the position of rest into the active position, each hole-opening arm has a face, internal to the body, designed to be subjected directly, in the same way as an active face of a piston, to the pressure of the drilling fluid flowing through the body.

Other details and particular features of the invention will become apparent from the appended claims and from the description of the schematic drawings attached to this text and which illustrate, by means of non-limiting example, at least one preferred embodiment of the hole opener of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows, in axial section, a hole opener, an arm visible in the figure being in the position of rest.

FIGURE 2 shows a partial axial section in which the visible arm is in the active position.

FIGURES 3 and 4 each show a cross section in which three hole-opening arms are depicted in the position of rest, and in the active position, respectively.

FIGURE 5 shows, to a larger scale and in longitudinal section, an assembly comprising an arm and an intermediate support so that arms can be mounted and exchanged quickly.

DETAILED DESCRIPTION OF THE INVENTION

In the various figures, the same references denote similar or analogous elements.

The hole opener 1, as depicted by way of example in FIGURES 1 to 4, comprises a body 2 of longitudinal axis 3, a duct 4 for drilling fluid, formed longitudinally in the body 2, and at least two hole-opening arms 5 which are distributed symmetrically in the body 2 about the longitudinal axis 3 to make sure that the operation of the hole opener 1 is approximately balanced. FIGURES 3 and 4 show that three arms 5 can easily be arranged in the body 2 with angles of 120° between two successive arms 5.

The arms 5 each have an active part 7 equipped with cutting mechanisms 8 (FIGURES 3 to 5) which are known and explained hereinbelow. The arms 5 are arranged in the body 2 so that they can be moved between a position of rest 9 in this body 2 and an active position 10 partially out of this same body 2.

Each arm 5 may comprise, for moving it from the position of rest 9 into the active position 10, a face 12 internal to the body 2 and designed to be subjected directly, in the same way as an active face of a piston, to the pressure of the drilling fluid flowing through the body 2. Through this arrangement, it is possible to avoid having intermediate mechanical parts between the fluid which is to actuate the arm 5 and this arm, and the problems known to those skilled in the art which may ensue.

The internal face 12 of the arm 5 should be understood as meaning any face/surface in contact, at

any moment in the drilling and/or hole-opening operation, with the pressurized fluid flowing through the duct 4. Some of these faces/surfaces subjected to the same pressure will compensate for each other but, overall, there remains enough positive area that, for example with a positive pressure differential of the order of 2 MPa (about 300 psi) between the pressure of the fluid in the duct 4 and that of the fluid outside the body 2 in the region of the arm or arms 5, a thrust force of the order of 2000 kg can be obtained, in order to deploy the arm 5 from the body 2.

The arm 5 is mounted in such a way that it can slide parallel to itself in the body 2, so as to move from the position of rest 9 into the active position 10 and vice versa. The choice of a movement of this kind is one of the more favorable types of movement, for operation in the manner of a piston.

The movement of the arm 5 can be directed radially and/or in any other favorable direction, whether this be upward or downward with respect to a direction of work of the hole opener, and/or forward or backward with respect to a direction of rotation of the hole opener, possibly in any combination of these directions of movement.

A movement of pivoting about an axis (not depicted) perpendicular to the longitudinal axis 3 and to the direction of the travel of the arm 5, and arranged somewhat away from the arm 5 is, however, also possible, but would require special machining of significantly higher cost than the machining of the previous embodiment in order to implement it.

In order to provide the aforementioned piston function, sealing means 11 are provided at places which are known to those skilled in the art.

To move it from the active position 10 into the position of rest 9 when the pressure in the duct 4 decreases, the or each arm 5 advantageously comprises elastic return means 13, for example compression coil springs 14 as depicted in the drawings. This arrangement allows the hole opener 1 to be withdrawn from the bore hole without difficulty.

The arm 5 may, in the active position 10 out of the body 2, have a posterior face 16 (with reference to a direction F of advance for opening out the hole) which is at an angle, designed, for example if the springs 14 should be deficient, to help the arm 5 back into the body 2 when the hole opener 1 is being withdrawn from the bore hole.

The arm 5 can be mounted in the body 2 by means of an intermediate support 15 which acts as a housing and a guide for the arm 5 in the body 2 and which is fixed to the latter, for example by screws 17. Sealing means 18 may then be provided between the body 2 and said intermediate support 15.

The fluid duct 4 has (FIGURES 2 and 4) a passage cross section of inside radius i. The term radius is to be understood in a broad sense, for example half the mean linear dimension of this passage cross section.

The arms 5 are guided, at least in the active position, in the body 2 or, as appropriate, in their respective intermediate support 15 over a distance g.

These same arms 5, in the active position, project from the body 2 by a length o.

As FIGURES 2 and 4 show,

- the sum s of the three values i, g and o corresponds to the radius or half the diameter of opening of the arms 5,
- the outside diameter of the body 2 is equal to (i + g) x 2 or to (s - o) x 2,
- thus, the projecting length o is equal to s - g - i.

The invention proposes to keep the three values i, g and o related to their sum s within respective determined values. This stems from various experiments which yielded fairly narrow ranges for the following three proportions:

$0.30 < i/s < 0.45$, $0.40 < g/s < 0.60$, $0.07 < o/s < 0.20$.

The value of o considered is the maximum possible value for the movement of the arm 5 in the hole opener.

Table 1 appended hereto gives, for seven hole openers of different sizes, ranging, in increasing size, from size 1 to size 7, characteristic dimensions and the corresponding proportions. It is evident from this that preference may be given to the following respective ranges for said proportions:

$0.34 < i/s < 0.39$, $0.45 < g/s < 0.53$, $0.10 < o/s < 0.16$.

For any other identical const ruction condition, proportions outside these ranges gave rise to hole openers which did not perform as well as those whose proportions fell within the above ranges, whether in terms of operational reliability, life, quality of work, performance, etc.

For its sliding guidance in the body 2 or in the intermediate support 15, each arm 5 may comprise a portion, preferably cylindrical, of diameter d, the value of which is advantageously at least equal to the value of g above. In doing this, attempts are made at making a weighty and robust arm 5.

This advantageously cylindrical portion of the arm 5, in the form of a piston, may be made of a steel, for example surface-hardened on the guide surface so as to reach a hardness of the order of at least 120 or even 140 or as much as 240 kg/mm2. The guide cavity of the body 2 or of the intermediate support 15, acting as cylinder for said piston, may be formed in a steel treated, for example, by through-hardening of the guide surface to obtain a hardness of at least 120 or preferably 140 kg/mm2.

Of course, the most favorable technical and economical combination is sought when choosing these hardnesses.

Prior to a hole-opening operation, each arm 5 is kept in the position of rest 9 in the body 2 by at least one pin 19 designed to break when the pressure of the drilling fluid flowing through the body 2 exceeds a predetermined value higher than a maximum usual boring value.

For this purpose, the pin 19 may have a region 19A of calibrated weakness, at the or each point of transition 20 where the pin 19 passes, as the case may be, either from the body 2 or from the intermediate support 15 into the arm 5. It is obvious that, unlike what has been depicted in F IGURES 3 and 4, the pin 19 does not necessarily have to emerge from both sides of the arm 5.

This pin 19 may fix the arm 5 merely to the intermediate support 15 (FIGURES 3 and 4).

FIGURE 4 shows the pin 19 broken into one part 19B in the arm and two parts 19C in the intermediate support 15.

The intermediate support 15, th e arm 5, the aforementioned elastic means 14 and the pin 19 may therefore constitute an assembly 21 (FIGURE 5) designed to be assembled beforehand outside the body 2 and then installed therein. This then makes the hole opener 1 not only easier to assemble, but also easier to maintain or repair in the event of damage, etc.

It must be understood that the present invention is not in any way restricted to the embodiments described hereinabove and that many modifications may be made thereto without departing from the scope of the claims given hereinbelow.

On its outer face, between two successive arms 5, the body 2 may have a longitudinal passage 22 for returning drilling fluid to the surface, and a boss 23 arranged in this passage 22 so as to divert and/or deflect the drilling fluid which is rising back up toward the surface onto that part of the wall of the

hole on which the arms 5 are acting. The passage 22 and the boss 23 are produced in such a way as not to form too great a restriction to the passage of the returning fluid.

In a particular embodiment of the hole opener 1, the travel of an arm 5 between the position of rest 9 and the active position 10 is limited in both directions of travel by stops. In the position of rest 9, the arm 5 is usually completely retracted into the body 2 and is held therein by reciprocal stop surfaces 25 (FIGURE 3) or, as appropriate, by the pin 19. In the active position 10, the arm 5, retained by reciprocal stop surfaces 26 (FIGURES 2 and 4), sweeps through an area, the largest diameter of which is equal to between 1.05 and 1.3 times, preferably 1.2 times the nominal diameter of a drill bit associated with the hole opener 1 for a combined drilling and hole-opening operation.

The cutting mechanisms 8 on the arms 5 are arranged by the person skilled in the art in such a way as, for example, to obtain cutting efficiency similar to that of the cutting means of the associated drill bit.

The reciprocal stop surfaces 26 may be arranged on exchangeable or adjustable elements so as to allow a user of the hole opener 1 to choose the extent to which the arms 5 can deploy out of the body 2 during service.

Table 1

Hole-opener size	1	2	3	4	5	6	7
Diameter of opening of the arms = s x 2	133.4	177.8	250.8	311.2	355.6	431.8	508.0
Diameter of the body = (s - o) x 2	119.1	149.2	212.7	266.7	308.0	371.5	428.6
Length by which the arms project out of the body = o i.e. (2s - (2s - 2o)):2	7.15	14.3	19.05	22.25	23.8	30.15	39.7
Guide distance = g	36.5	41.9	60.35	75.35	86.0	104.65	115.8
Inside passage radius = i	23.05	32.7	46.0	58.0	68.0	81.1	98.5
Sum s = o + g + i	66.7	88.9	125.4	155.6	177.8	215.9	254.0
o/s	0.107	0.161	0.152	0.143	0.134	0.140	0.156
g/s	0.547	0.471	0.481	0.484	0.484	0.485	0.456
i/s	0.346	0.368	0.367	0.373	0.382	0.375	0.388

Key to the figures

1	hole opener
2	body
3	longitudinal axis
4	duct
5	hole-opening arms
7	active part
8	cutting means
9	position of rest
10	active position
11	sealing means
12	internal face
13	elastic return means
14	coil springs
15	intermediate support
16	posterior face
17	screws
18	sealing means
19	pin
19A	weakened region(s)
19B	part of the pin
19C	part of the pin
20	transition point
21	assembly
22	longitudinal passage
23	boss
25	reciprocal stop surfaces
26	reciprocal stop surfaces
S	direction of advance of a hole-opening/boring process